Remarks

Claims 14-31 have been canceled without prejudice and replaced with claims 32-45.

New claim 32 corresponds to former claim 14 and has been drafted to more particularly point out and distinctly claim the structural features of the claimed tablet machine. Support is found in the specification in the paragraph bridging pages 3-4, Figures 1-3, pages 5-6 and on page 24, lines 5 to 27.

Claims 33-37 correspond to former claims 21-25, respectively.

Claim 38 is supported at page 11, lines 12-15 of the specification.

Claims 39-41 correspond to former claims 26-29, respectively.

Claims 42-44 are supported at page 23, line 20 to page 24, line 1.

Claim 45 corresponds to former claim 31.

The objection to claims 15-20 and 26-31 is deemed to be overcome in view of the wording of the new claims.

Claims 21-24 were rejected under 35 U.S.C. § 112, second paragraph, as being indefinite based upon the recitation of the limitation "A_3". This ground of rejection is respectfully traversed.

The meaning of the term "A_3 transformation temperature" is quite apparent to those skilled in the art. See for example claim 1 of US 5,592,840; claim 1 of US 6,018,854; and claim 1 and column 2, line 28 of US 6,679,957 B1, copies of which are enclosed herewith. Thus, it is respectfully submitted that the limitation is clear and definite to those skilled in this art field.

Claims 14-20 and 26-31 were rejected under 35 U.S.C. § 102 as being anticipated by Payson, or Kunitake et al., or EP 338133.

This ground of rejection is respectfully traversed as applied to the new claims presented.

The cited references fail to disclose a tablet machine having the structure according to new claim 32. In particular, the cited references fail to disclose or suggest a tableting machine having an upper punch, a lower punch and a die whose surfaces contacting the granules are carburized. Furthermore, the cited references fail to disclose or suggest a tableting machine having an upper punch, a lower punch and a die which are comprised of high silicon steel and whose surfaces contacting the granules are carburized, according to new claim 32.

Moreover, the cited references fail to disclose or suggest a tableting machine for compressing tablets, wherein the carburized surfaces of the upper punch, the lower punch and the die comprise a concentrated carbon layer having a thickness in a range of 5 to 100 microns, according to new claim 38.

Nor do the cited references disclose or suggest a method for manufacturing tablets, using granules containing an adhesive or corrosive substance in the tableting machine according to claim 32, as described in claim 39.

The present invention is aimed at overcoming the problems in the prior art of manufacturing tablets from granules containing corrosive or adhesive substances. Such problems involved corrosion of the punches and die of the tableting machine by the corrosive substances, and sticking of the compressed tablet to the punches and die by the adhesive substances.

The present invention has been accomplished by the inventor's discovery that forming the punches and die from a high silicon steel, and carburizing the surfaces of the punches and die, unexpectedly improve the corrosion resistance of these parts, as well as improve the release of the tablet from these parts. See the specification at pages 1-3.

In view of the foregoing, it is respectfully submitted that the new claims are novel and nonobvious from the prior art. According reconsideration and withdrawal of this ground of rejection is solicited.

Lastly, claims 21-25 are rejected under 35 U.S.C. § 103 as being unpatentable over EP 338133.

This ground of rejection is deemed to be overcome in view of the wording of the new claims presented. Specifically, new claims 33-37 corresponding to former claims 21-25 are dependent upon new claim 32. New claim 32 is patentable over the prior art for the reasons set forth above. Accordingly, dependent claims 33-37 are patentable over the prior art.

In view of the foregoing comment it is believed that each ground of rejection set forth in the Official Action have been overcome, and that the application is now in condition for allowance. Accordingly, such allowance is solicited.

Respectfully submitted,

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the invention herein described, and all statements of the scope of the invention which, as a matter of language, might be said to fall therebetween.

What is claimed is:

1. A method for preventing abrasion of a metal-product, made of ferrous metal having an A_3 transformation temperature or made of nonferrous metal having a recrystallization temperature, said metal-product having a portion which is to be subjected to sliding action, said portion having a surface, said method comprising:

subjecting said portion of said metal-product to shot peening thereby resulting in

an increase in temperature at the surface of said portion of said metal-product to a temperature at least as high as (a) A_3, the transformation temperature of the metal of said metal product in the case that said metal-product is made of a ferrous metal, or (b) the recrystallization temperature of said metal of said metal product in the case that said metal-product is made of a nonferrous metal, and

formation of a plurality of concave sumps on said surface of said portion, each sump having a circular arc-shaped cross section,

said shot-peening comprising projecting shots under pressure at a velocity of at least 50 m/sec whereby said shots impact against said surface of said portion, said shots having a hardness at least as high as that of said metal-product, a substantially spherical shape, and a size of 20 to 200μ.

2. A method for preventing abrasion according to claim 1, further comprising subjecting said surface of said portion of said metal-product to at least one more further shot-peening.

3. A method for preventing abrasion according to claim 2, wherein, in said further shot-peening, shots are expelled at a pressure at least as high as the pressure of the prior shot-peening.

4. A method according to claim 2, wherein said further shot-peening is performed using alumina-silica beads as said shots.

5. A method for preventing abrasion according to claim 1, further comprising supplying lubricating oil to said surface of said portion of said metal-product so that an oil film is formed on said surface.

6. A metal product produced according to the method of claim 5.

7. A method for preventing abrasion according to claim 1, wherein said shots are spherical.

8. A method for preventing abrasion according to claim 1, wherein said shots are expelled at a velocity of 100 to 200 m/sec.

9. A method for preventing abrasion according to claim 1, wherein said size of said shots is 28 to 125μ.

10. A method for preventing abrasion according to claim 1, wherein said shots are expelled from a nozzle having an internal diameter of 5 to 9 mm.

11. A method for preventing abrasion according to claim 10, wherein the distance from said nozzle to said surface of said portion is 150–200 mm.

12. A method for preventing abrasion according to claim 10, wherein said shots are expelled at a pressure of 3 to 6 kg/cm^2.

13. A method for preventing abrasion according to claim 11, wherein after said shot-peening, a further shot-peening is performed wherein shots are expelled from a nozzle and the distance from said nozzle to said surface is at least as large as the distance in the prior shot-peening.

14. A method for preventing abrasion according to claim 11, wherein said shots are expelled at a velocity of 100 to 200 m/sec.

15. A method for preventing abrasion according to claim 14, wherein said size of said shots is 28 to 125μ.

16. A method for preventing abrasion according to claim 1, wherein said shots are manufactured from metal, ceramic or glass.

17. A method according to claim 1, wherein each concave sump has a substantially circular top perimeter of 0.1 to 5μ in size.

18. A method according to claim 1, wherein said said surface of said portion has a roughness higher than that of said surface before said shot-peening.

19. A method according to claim 18, wherein, after said shot-peening, said surface has a roughness at least as high as 0.1μ.

20. A metal product produced according to the method of claim 1.

21. A method according to claim 1, wherein said shots exhibit a hardness of at least 700 Hv.

22. A method according to claim 1, wherein the hardness of said surface after said shot-peening is greater than the hardness of said surface before said shot-peening.

23. A method for increasing the abrasion resistance of a surface of a metal product, said method comprising:

subjecting said surface to shot-peening whereby the temperature of said surface is increased and the surface is softened, said shot-peening resulting in formation of a plurality of concave structures having circular arc-shaped cross sections on said surface and also resulting in an increase in internal stress,

wherein, in said shot-peening, substantially spherical shots having a size of 20–200μ are impacted against said surface at a velocity of at least 50 m/s.

24. A method according to claim 23, wherein said metal product is made of ferrous metal and, during said shot-peening, the temperature of said surface is increased to at least the A_3 transformation temperature of said ferrous metal.

25. A method according to claim 23, wherein said metal product is made of nonferrous metal and, during said shot-peening, the temperature of said surface is increased to at least the recrystallization temperature of said nonferrous metal.

26. A method according to claim 1, wherein, prior to said shot-peening, said surface is provided with concave portions having V-shaped cross sections.

* * * * *

Furthermore, the consumed quantity of the shot in the present shot B is one fifth of that in the prior art shot B. Consequently, the durability of the metal shot surface-treated by the method of the present invention can be improved and stable surface-hardening can be applied to the surface of the metal shot material by the method of the present invention although the present shot B has a small diameter.

TABLES 11 and 12 show still another example of comparison. A present shot C and a prior art shot C differ from the present shots A and B and the prior art shots A and B in the foregoing examples of comparison respectively. In this example, a shaft is employed as the metal product. TABLE 11 shows the conditions of the blasting common to the present and prior art metal shots:

TABLE 11

Type of the blasting machine	straight hydraulic type
Name of the metal product	cemented gear (external diameter of ϕ15 and length of 100 mm)
Material of the product	SUS304 (stainless steel)
Surface hardness of the product	350 Hv
Diameter of the nozzle	5 mm; only one nozzle used
Blasting distance	150 mm
Treating time	30 sec. per product
Grain diameter of metal shot	0.2 mm (#80)

The following TABLE 12 shows the conditions of the blasting different between the present metal shot and the prior art metal shot:

TABLE 12

	Prior art shot C	Present shot C
Material	stainless steel beads	stainless steel beads
Hardness	250 to 350 Hv	450 to 550 Hv
Blasting pressure	4 kg/cm^2	3 kg/cm^2
Blasting speed	130 m/s	110 m/s
Product's Surface stress	800 MPa	800 MPa
Product's surface structure	martensite	martensite
Product's surface hardness	500 Hv	500 Hv
Product's arc height	0.10 N	0.10 N
Consumed quantity of the shot	1	½

As is obvious from TABLES 11 and 12, even when the blasting pressure is rendered lower in the present shot C than in the prior art shot C as in the foregoing examples, the stress of the treated surface, the surface structure, and the surface hardness of the product in the present shot C are equal to those in the case of the prior art shot C. Furthermore, the consumed quantity of the shot in the present shot C is one half of that in the prior art shot C. Consequently, the durability of the metal shot surface-treated by the method of the present invention can be improved and stable surface-hardening can be applied to the surface of the metal shot material by the method of the present invention although the present shot C has a small diameter.

The foregoing description and drawings are merely illustrative of the principles of the present invention and are not to be construed in a limiting sense. Various changes and modifications will become apparent to those of ordinary skill in the art. For instance, the metal shot material, be it ferrous or non-ferrous, can be blasted against a metal body/bodies having a hardness at least equal to that of the metal shot material. In this case, the metal shot material may be provided in the first container of a blasting machine similar to that shown in FIGS. 1 and 2. A metal body or bodies such as gears (simply referred to hereinafter as body) is/are provided in the second container. The metal shot material is blasted against the metal body under such conditions, e.g. at a blasting speed of at least 80 m/s and under the other conditions set out in the examples above, that the surface temperature of the metal shot material itself is increased. When the metal shot material is ferrous, the blasting conditions are set to increase the temperature of the shot material at its surface to above the A_3 transformation temperature of the metal shot material. In the case when the shot material is non-ferrous, the temperature at the surface of the non-ferrous shot material increases to above the recrystallization temperature of the material or a constituent, such as a binding agent, thereof. Accordingly, the metal shot material becomes a surface-hardened shot product. All such changes and modifications are seen to fall within the true spirit and scope of the invention as defined by the appended claims.

What is claimed is:

1. A method of making surface-hardened metal shot, said method comprising:
   accommodating a predetermined quantity of shot in a first container of a blasting machine;
   accommodating a predetermined quantity of ferrous metal shot material in a second container of the blasting machine, the shot having a hardness that is at least equal to that of the ferrous metal shot material; and
   blasting the shot accommodated in the first container against the ferrous metal shot material accommodated in the second container at a speed sufficient to increase the temperature of the ferrous metal shot material in the vicinity of the surface thereof to at least an A_3 transformation temperature of the ferrous metal shot material so as to harden the ferrous metal shot material and form surface-hardened metal shot.

2. The method according to claim 1, wherein the shot is of the same material and has the same grain diameter as the ferrous metal shot material.

3. The method according to claim 1, wherein the shot is of the same material as and has a grain diameter different from the ferrous metal shot material.

4. The method according to claim 1, wherein the shot comprises a metal which is different from the ferrous metal shot material and has the same grain diameter as the metal shot material.

5. The method according to claim 1, wherein the shot comprises a metal which is different from the ferrous metal shot material and has a grain diameter different from that of the ferrous metal shot material.

6. The method according to claim 1, wherein each of the ferrous metal shot material and the shot has a grain diameter of 0.3 mm or smaller.

7. The method according to claim 1, and further comprising agitating the ferrous metal shot material during said blasting.

8. The method according to claim 1, and further comprising recovering part of the ferrous metal shot material and part of the shot blasted against the ferrous metal shot material; and blasting the recovered shot and metal shot material against the unrecovered shot and ferrous metal shot material repeatedly.

9. The method of claim 1, wherein said step of blasting comprises blasting the shot against the ferrous metal shot material while the ferrous metal shot material is accommo-

furnace and the coils are left to cool down slowly. In any case, the coils are taken out of the furnace at a given temperature, as will be seen later.

Consequently, in the case of passive annealing, the heating temperature of the furnace is between 600 and 860° C., according to the type of steel, and the strip is kept at this temperature for less than 30 min, after which the furnace and strip are left to cool down for 8–28 hours, to obtain a maximum temperature of the strip, when it is taken out of the furnace, of less than 520° C.

In the case of isothermal annealing, instead, the heating temperature of the furnace is between 580 and 830° C., according to the type of steel, the coils being kept at this temperature for 4–15 hours, after which the furnace and strip are left to cool down for 4–16 hours, to obtain a maximum temperature of the strip, when it is taken out of the furnace, of less than 650° C.

Finally, in the case of total annealing, the furnace is heated at a temperature of between 600 and 850° C., according to the type of steel, the coils being kept at this temperature for 4–15 hours, after which the furnace and strip are left to cool down for 4–16 hours, to obtain a maximum temperature of the strip, when it is taken out of the furnace, of less than 650° C.

It has moreover been found that the effectiveness of the process according to the present invention is improved if the coils are put into the furnace in a horizontal position. The improvement obtained is due, according to some experimental data, to the fact that, with the coils arranged in this way, circulation of the atmosphere inside the hole present around the axis of the coils is enhanced, so favouring a better uniformity of the thermal gradient along the radius of the coils themselves.

EXAMPLES

Stainless Steel

Strips of stainless steel AISI 430, both continuously cast and hot-rolled to a thickness of 3.0 mm, were wound in coils at a temperature of 840° C. and transferred to an annealing furnace within 15 minutes from the end of winding. In the case of passive annealing, the temperature of the furnace was 840° C., and the coils put in the furnace remained there for 24 hours and were subsequently taken out at a temperature of approximately 500° C. and left to cool off in air.

In the case of isothermal annealing, the furnace was pre-heated to a temperature of 820° C., and the coils were kept at this temperature for approximately 12 hours. The furnace was then turned off and left to cool down spontaneously for 22 hours, and the coils were then taken out of the furnace at a temperature of approximately 500° C. and left to cool off in air.

In the case of total annealing, i.e., with temperature rising, the coils, which were put in the furnace when the latter was already hot, were heated again at the winding temperature (840° C.) and left at this temperature for 12 hours, after which the furnace was turned off and the coils were left to cool down at a cooling rate of approximately 15° C./h, and were then taken but of the furnace at a temperature of approximately 640° C. and left to cool off in air.

Table 1 below gives the mechanical characteristics measured on the steels obtained in the tests described above, cold-rolled to 0.6 mm and annealed, as well as the results obtained from conventional static annealing.

In this table, by "Rp0.2" is meant the load necessary to obtain an irreversible deformation of 0.2% in the original

length of the test specimen; by "Rm" is meant the breaking load of the specimen; and by "% el." is meant the permanent percentage elongation of the test specimen at failure.

TABLE 1

	Rp0,2 (MPa)	Rm (MPa)	% el.
Passive annealing	346 ± 23	506 ± 20	27.5 ± 1.7
Isothermal annealing	327 ± 23	500 ± 15	27.5 ± 2.1
Total annealing	338 ± 23	524 ± 17	26.8 ± 1.2
Traditional annealing	330 ± 20	520 ± 20	27.0 ± 2.0

As may be seen, the characteristics of the steels treated according to the present invention are perfectly in line with those obtained with traditional annealing.

Non-oriented-grain Magnetic Steels

Strips of steel containing 1% silicon, of the classes with improved permeability, for which annealing of the hot strip is already known in the art, were treated.

The strips were wound at a temperature of between 700 and 780° C. and transferred within 13 minutes into a furnace, pre-heated to a temperature of between 680 and 700° C. The time during which the strips were kept in the furnace, for isothermal annealing, was between 2 and 6 hours. In this way, it was possible to maximize the intensity of the texture (001) [100] and to minimize the texture <111>, so obtaining peak permeability consistently higher than 2440 gauss/oersted in the finished product, for which the traditional permeability values are between 2300 and 2500 gauss/oersted.

Carbon Steels

Strips of carbon steel of the types C70 and 35CD4, both continuously cast and hot-rolled, were isothermally annealed.

For the C70 steel, the strips were wound at a temperature of 700–720° C. and transferred to the furnace, which had been pre-heated to approximately 720° C. The coils were kept in the furnace for between 2 and 4 hours at a temperature of approximately 700° C., allowed to cool down to 630° C., and then taken out of the furnace and left to cool off in air. The final structure obtained was approximately 85–90% fine perlite. The mechanical characteristics obtained were altogether similar to those obtained with traditional annealing methods, either static or continuous.

For the 35CD4 steel, the strips were wound at a temperature of 720–740° C. and then transferred to the furnace, which had been pre-heated to approximately 730 ° C. The coils were kept in the furnace for between 3 and 5 hours at a temperature of approximately 720° C., allowed to cool down to 620° C., and then taken out of the furnace and left to cool off in air. The final structure obtained was fine perlite. The mechanical characteristics obtained were altogether similar to those obtained with traditional annealing methods, either static or continuous.

What is claimed is:

1. A process for the treatment of high temperature coiled steel strip of any type, comprising the following steps: (i) winding of the strip at a temperature from above 600° C. to the transformation temperature A3; (ii) transferring the coils in an annealing furnace within less than 30 minutes from winding, the furnace being heated to a temperature of

PROCESS FOR THERMAL TREATMENT OF STEEL STRIP

SCOPE OF INVENTION

The present invention refers to a process for the thermal treatment of steel strip and, more precisely, refers to the thermal treatment both of as cast steel strip using the so-called strip-casting technique, and of hot-rolled strip. The process is moreover suited for the treatment of any type of steel.

STATE OF THE ART

Normally, steel strip, either directly continuously cast or hot-rolled, is wound, when it is still at a high temperature, in coils which are left to cool down at room temperature. However, as is well known to those skilled in the field, the strips thus rolled do not possess characteristics suitable for a subsequent cold-rolling treatment, in particular as regards their microstructure, homogeneity of composition, and their mechanical characteristics. Consequently, it is necessary to bring the coils to a high temperature for a time sufficient for bringing about the necessary changes, with a treatment referred to as annealing.

Annealing may be either of the continuous type or of the discontinuous type. Continuous annealing is carried out in a furnace heated at a high temperature, through which the strip is made to pass at a certain speed. Continuous annealing permits a uniform quality of the treated strip and a limited treatment time, but entails large and costly plants.

In discontinuous annealing, the strip is wound into coils, which are then loaded into a furnace. In this case, the plant is simple, not particularly cumbersome, and relatively economical, but the process of treatment is very long, generally in the region of a few dozen hours, and the end quality of the product is uneven.

For the treatment of strip that is directly continuously cast or hot-rolled, the annealing method most widely used is the discontinuous one, which presents evident disadvantages in terms of waste of energy, time and resources, and the resulting quality is not uniform.

A possible solution to the problems referred to above may be that of transporting the coils from the winding stage to the annealing furnace without allowing them to cool down excessively.

In this connection, so far attention has been focused on the treatment of stainless steels, or in any case corrosion-resistant steels. For example, the published Japanese patent application No. 52-65126 describes a process for the thermal treatment of stainless steels (of the types SUS 410 and SUS 430), in which the stainless-steel coils are loaded still hot into the annealing furnace. Likewise, the European patent application No. 343 008 refers to the treatment of hot-rolled stainless-steel strip, or in any case corrosion-resistant strip, in which the strip is hot-rolled above the transformation temperature A3 and then cooled down at a rate of between 10 and 1 ° C./min, in order to prevent the presence of martensite. This is obtained by isolating the strip against excessive heat losses, at least in part enclosing it in a thermally insulated casing.

The experience acquired through long experiments carried out by the present applicant has revealed that the teaching that may be drawn from the known art does not appear satisfactory, in particular for strip of small thickness, for example less than 3 mm. Furthermore, the known art is

declaredly applicable only to stainless steels, or in any case corrosion-resistant steels. In addition to these points, the applicant has identified a number of process parameters not taken into consideration by the known art, which appear essential in order to achieve high-quality results.

The purpose of the present invention is, therefore, to enable hot treatment of steels of any type, cast directly in continuous casting or hot-rolled, in particular to small thicknesses, to obtain in the treated strip an excellent uniformity of composition and microstructure, in particular the absence of martensite, and hence high and uniform mechanical properties, not inferior to those obtainable from traditional annealing processes.

Amongst the advantages of the present invention, which are obvious to those skilled in the field, we recall that of an important energy saving.

DESCRIPTION OF THE INVENTION

According to the present invention, the process for thermal treatment of strip, in particular strip of small thickness, of any type of steel, in particular carbon-manganese steels or carbon steels alloyed with nickel and/or chrome and/or molybdenum, non-oriented-grain silicon magnetic steels, and stainless steels, wound on coils when still at a high temperature, is characterized by the combination in a co-operation relationship, of the following steps: (i) winding of the strip at a temperature of between 600° C. and the transformation temperature A3; (ii) transfer of the coils into an annealing furnace in a time of less than 30 minutes from winding, preferably less than 20 minutes, the furnace being heated to a temperature of between 560 and 870° C. and maintaining the pre-selected temperature of steel for a pre-selected time; (iii) taking the coils out of the furnace at a temperature of less than 650° C.

The temperature to which the furnace is to be heated depends upon the type of steel that is being treated and, in particular, in the case of stainless steels is between 650 and 850° C., preferably between 800 and 850° C.; for carbon steels it is between 570 and 760° C., preferably between 670 and 730° C.; for non-oriented-grain magnetic steels, it is between 660 and 830° C., preferably between 670 and 710° C.

Since according to the present invention it is possible to treat any type of steel, we shall now give the winding temperatures necessary for three important types of steel, i.e., carbon steels, non-oriented-grain magnetic steels, and stainless steels. For carbon steels, the coil winding temperature is between 600 and 770° C., preferably between 700 and 750° C.; for non-oriented-grain magnetic steels, the coil winding temperature is between 700 and 850° C.; and for stainless steels, the coil winding temperature is between 650 and 850° C.

In addition, according to the present invention it is possible to anneal the steel according to any one of the possible ways, and namely, passive annealing, in which the hot coil is charged into the furnace heated to a high temperature, the heat tranfer to the furnace after charging the coils being negligible or zero, so that the temperature of the furnace, and hence of the strip, slowly decreases in time; isothermal annealing, in which, after charging the coils into the furnace, the temperature of the furnace is kept at a desired level for a pre-set time, after which the temperature of the coils slowly decreases in time; and total annealing, in which after charging the coils into the furnace, the temperature of the furnace and hence of the coils is raised for a given period of time, until a pre-selected value is reached, after which the